JERRY A. HAUSMAN
Massachusetts Institute of Technology
Department of Economics
Building E52-271A
Cambridge 02139
(617) 253-3644

EDUCATION:

OXFORD UNIVERSITY
D. Phil. 1973 (Ph.D)
B. Phil. 1972

BROWN UNIVERSITY
A.B. (Summa Cum Laude), 1968

THESIS: "A Theoretical and Empirical Study of Vintage Investment and Production in Great Britain,"
Oxford University, 1973.

FELLOWSHIPS, HONORS AND AWARDS:

Phi Beta Kappa
Marshall Scholar at Oxford, 1970-1972
Scholarship at Nuffield College, Oxford, 1971-1972
Fellow of Econometric Society, 1979.
Frisch Medal of the Econometric Society, 1980
Fisher-Schultz Lecture for the Econometric Society, 1982
John Bates Clark Award of the American Economic Association, 1985
Jacob Marschak Lecture for the Econometric Society, 1988
American Academy of Arts and Sciences, 1991.
Fellow, Journal of Econometrics, 1998.

EMPLOYMENT:

	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
1992-	John and Jennie S. MacDonald Professor
1979-	Professor, Department of Economics
1976-79	Associate Professor, Department of Economics
1973-76	Assistant Professor, Department of Economics
1972-73	Visiting Scholar, Department of Economics

	VISITING APPOINTMENTS:
1986-87	Visiting Professor, Harvard Business School
1982-83	Visiting Professor, Harvard University Department of Economics

	U.S. ARMY, ANCHORAGE, ALASKA
1968-70	Corps of Engineers

PROFESSIONAL ACTIVITIES:

Associate Editor, Bell Journal of Economics, 1974-1983
Associate Editor, Rand Journal of Economics, 1984-1988
Associate Editor, Econometrica, 1978-1987
Reviewer, Mathematical Reviews, 1978-1980
American Editor, Review of Economic Studies, 1979-82
Associate Editor, Journal of Public Economics, 1982-
Associate Editor, Journal of Applied Econometrics, 1985-1993
Member of MIT Center for Energy and Environmental Policy Research, 1973-
Research Associate, National Bureau of Economic Research, 1979-
Member, American Statistical Association Committee on Energy Statistics, 1981-1984
Special Witness (Master) for the Honorable John R. Bartels, U.S. District Court for the Eastern
District of New York in Carter vs. Newsday, Inc., 1981-82
Member of Governor's Advisory Council (Massachusetts) for Revenue and Taxation,
1984-1992
Member, Committee on National Statistics, 1985-1990
Member, National Academy of Social Insurance, 1990-
Member, Committee to Revise U.S. Trade Statistics 1990-1992
Director, MIT Telecommunications Economics Research Program, 1988-
Board of Directors, Theseus Institute, France Telecom University, 1988-1995
Member, Conference on Income and Wealth, National Bureau of Economic Research, 1992-

PUBLICATIONS:

I. Econometrics

"Minimum Mean Square Estimators and Robust Regression," Oxford Bulletin of Statistics, April 1974.

"Minimum Distance and Maximum Likelihood Estimation of Structural Models in Econometrics," delivered at the European Econometric Congress, Grenoble: August 1974.

"Full-Information Instrumental Variable Estimation of Simultaneous Equation Models," Annals of Economic and Social Measurement, October 1974.

"Estimation and Inference in Nonlinear Structural Models," Annals of Economic and Social Measurement, with E. Berndt, R.E. Hall, and B.H. Hall, October 1974.

"An Instrumental Variable Approach to Full-Information Estimators in Linear and Certain Nonlinear Econometric Models," Econometrica, May 1975.

"Simultaneous Equations with Errors in Variables," delivered at Winter Econometric Meetings, San Francisco: December 1974; published in Journal of Econometrics 5, 1977, pp. 389-401.

"Social Experimentation, Truncated Distributions, and Efficient Estimation," delivered at the World Econometric Congress, Toronto: August 1975; Econometrica, with D. Wise, June 1977.

"A Conditional Probit Model for Qualitative Choice," delivered at World Econometric Congress, Toronto: August 1975; MIT Working Paper 173, April 1976; Econometrica, with D. Wise, March 1978.

"Specification Tests in Econometrics," MIT Working Paper 185, June 1976; Econometrica, 1978.

"Non-Random Missing Data," with A.M. Spence, MIT Working Paper 200, May 1977.

PUBLICATIONS cont.:

"Attrition Bias in Experimental and Panel Data: The Gary Income Maintenance Experiment," with D. Wise, J.F. Kennedy School Working Paper, May 1977; Econometrica, January 1979.

"Missing Data and Self Selection in Large Panels," with Z. Griliches and B.H. Hall, Harvard Economics Department Working Paper, August 1977; delivered at INSEE conference on Panel Data, Paris: August 1977; Annales de l'INSEE, April 1978.

"Stratification on Endogenous Variables and Estimation," with D. Wise, J.F. Kennedy School Working Paper, January 1978; delivered at CME Conference, April 1978; in The Analysis of Discrete Economic Data, ed. C. Manski and D. McFadden, MIT Press, 1981.

"Les models probit de choix qualitatifs," ("Alternative Conditional Probit Specifications for qualitative Choice.") (English Version), September 1977; EPRI report on discrete choice models, presented at INSEE Seminar, Paris: May 1978; Cahiers du Seminar d'Econometrie, 1980.

"The Econometrics of Labor Supply on Convex Budget Sets," Economic Letters, 1979.

"Panel Data and Unobservable Individual Effects," with W. Taylor, MIT Working Paper 225; Econometrica 49, November 1981.

"Comparing Specification Tests and Classical Tests," with W. Taylor, August 1980, Economic Letters, 1981.

"The Effect of Time on Economic Experiments," invited paper at Fifth World Econometrics Conference, August 1980; in Advances in Econometrics, ed. W. Hildebrand, Cambridge University Press, 1982.

"Sample Design Considerations for the Vermont TOD Use Survey," with John Trimble, Journal of Public Use Data, 9, 1981.

"Identification in Simultaneous Equations Systems with Covariance Restrictions: An Instrumental Variable Interpretation," with W. Taylor, December 1980; Econometrica, 1983.

"Stochastic Problems in the Simulation of Labor Supply," presented at NBER conference, January 1981; in Tax Simulation Models, ed. M. Feldstein, University of Chicago Press, 1983.

"The Design and Analysis of Social and Economic Experiments," invited paper for 43rd International Statistical Institute Meeting, 1981; Review of the ISI.

"Specification and Estimation of Simultaneous Equation Models," in Handbook of Econometrics, ed. Z. Griliches and M. Intriligator, vol. 1, 1983.

"Full-Information Estimators," in Kotz-Johnson, Encyclopedia of Statistical Science, vol. 3, 1983

"Instrumental Variable Estimation," in Kotz-Johnson, Encyclopedia of Statistical Science, vol. 4, 1984

"Specification Tests for the Multinomial Logit Model," with D. McFadden, October 1981; Econometrica, 1984.

"Econometric Models for Count Data with an Application to the Patents R&D Relationship," with Z. Griliches and B. Hall, NBER Working Paper, August 1981; Econometrica, 1984.

"The Econometrics of Nonlinear Budget Sets," Fisher-Shultz lecture for the Econometric Society, Dublin: 1982; Econometrica, 1985.

"The J-Test as a Hausman Specification Test," with H. Pesaran, November 1982; Economic Letters, 1983.

PUBLICATIONS cont.:

"Seasonal Adjustment with Measurement Error Present," with M. Watson, May 1983; Journal of the American Statistical Association, 1985.

"Efficient Estimation and Identification of Simultaneous Equation Models with Covariance Restrictions," with W. Newey and W. Taylor, October 1983; Econometrica, 1987.

"Technical Problems in Social Experimentation: Cost Versus Ease of Analysis," with D. Wise, in Social Experimentation, ed. J. Hausman and D. Wise, 1985.

"Errors in Variables in Panel Data," with Z. Griliches, Journal of Econometrics, 1986.

"Specifying and Testing Econometric Models for Rank-Ordered Data," with P. Ruud; Journal of Econometrics, 1987.

"Semiparametric Identification and Estimation of Polynomial Errors in Variables Models," with W. Newey, J. Powell and H. Ichimura, 1986, Journal of Econometrics, 1991.

"Flexible Parametric Estimation of Duration and Competing Risk Models," with A. Han, November 1986, revised January 1989, Journal of Applied Econometrics, 1990.

"Consistent Estimation of Nonlinear Errors in Variables Models with Few Measurements," with W. Newey and J. Powell, 1987.

"Optimal Revision and Seasonal Adjustment of Updated Data: Application to Housing Starts," with M. Watson, Journal of the American Statistical Association Proceedings, 1991.

"Seasonal Adjustment of Trade Data," with R. Judson and M. Watson, ed. R. Baldwin, Behind the Numbers: U.S. Trade in the World Economy, 1992.

"Nonlinear Errors in Variables: Estimation of Some Engel Curves," Jacob Marschak Lecture of the Econometric Society, Canberra 1988, Journal of Econometrics, 65, 1995.

"Nonparametric Estimation of Exact Consumers Surplus and Deadweight Loss," with W. Newey, 1992, Econometrica, 1995.

"Misclassification of a Dependent Variable in Qualitative Response Models," with F. Scott-Morton and J. Abrevaya, mimeo December 1993, Journal of Econometrics, 1998.

"Semiparametric Estimation in the Presence of Mismeasured Dependent Variables," presented at NSF Conference, 1995, with J. Abrevaya, forthcoming in Annales D'Economie et de Statistique.

"Response Error in a Transformation Model: Estimation of Wage Equations," with Jason Abrevaya, mimeo 1998.

"A New Specification Test for the Validity of Instrumental Variables," with J. Hahn, mimeo, May 1999.

II. Public Finance

"The Evaluation of Results from Truncated Samples," with D. Wise, Annals of Economic and Social Measurement, April 1976.

"Discontinuous Budget Constraints and Estimation: The Demand for Housing," with D. Wise, J.F. Kennedy School Working Paper, July 1977; Review of Economic Studies, 1980.

PUBLICATIONS cont.:

"The Effect of Taxation on Labor Supply: Evaluating the Gary Negative Income Tax Experiment," with G. Burtless, October 1977; Journal of Political Economy, December 1978.

"AFDC Participation -- Permanent or Transitory?," delivered at NBER-NSF Conference, August 1978; in Papers from the European Econometrics Meetings, ed. E. Charatsis, North Holland: 1981.

"The Effect of Wages, Taxes, and Fixed Costs on Women's Labor Force Participation," March 1979; presented at SSRC-NBER Conference on Taxation, Cambridge, England: June 1979; Journal of Public Economics, October 1980.

"The Effect of Taxes on Labor Supply," presented at Brookings Conference, October 1979; published in How Taxes Affect Economic Behavior, ed. H. Aaron and J. Pechman, Brookings: 1981.

"Income and Payroll Tax Policy and Labor Supply," presented at St. Louis Fed. conference, October 1980; in The Supply Side Effects of Economic Policy, ed. G. Burtless, St. Louis: 1981.

"Individual Retirement Decisions Under an Employer-Provided Pension Plan and Social Security," with G. Burtless, Journal of Public Economics, 1982.

"Individual Retirement and Savings Decisions," with P. Diamond, October 1981; presented at SSRC-NBER Conference on Public Economics, Oxford: June 1982; Journal of Public Economics, 1984.

"Retirement and Unemployment Behavior of Older Men," with P. Diamond, presented at Brookings Conference on the Aged, November 1982; in H. Aaron and G. Burtless, Retirement and Economic Behavior, Brookings: 1984.

"Tax Policy and Unemployment Insurance Effects on Labor Supply," May 1983; in Removing Obstacles to Economic Growth, ed. M. Wachter, 1984.

"Family Labor Supply with Taxes," with P. Ruud, American Economic Review, 1984.

"Social Security, Health Status and Retirement," with D. Wise, in Pensions, Labor, and Individual Choice, ed. D. Wise, 1985.

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"A Utility-Consistent Combined Discrete Choice and Count Data Model: Assessing Recreational Use Losses Due to Natural Resource Damage," with G. Leonard and D. McFadden, Journal of Public Economics, 56, 1995.

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"A Cost of Regulation: Delay in the Introduction of New Telecommunications Services," with T. Tardiff, 1995, ed. A. Dumort and J. Dryden, The Economics of the Information Society, 1997.

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"Efficiency Effects on the U.S. Economy from Wireless Taxation", presented at NBER conference, November 1999.

III. Applied Micro Models

"Project Independence Report: A Review of U.S. Energy Needs up to 1985," Bell Journal of Economics, Autumn 1975.

"Individual Discount Rates and the Purchase and Utilization of Energy Using Durables," MIT Energy Laboratory Working Paper, January 1978; Bell Journal of Economics, Spring 1979.

"Voluntary Participation in the Arizona Time of Day Electricity Experiment," with D. Aigner, May 1978; delivered at EPRI Conference on Time of Day Pricing, June 1978; in EPRI Report, Modeling and Analysis of Electricity Demand by Time of Day, 1979; Bell Journal of Economics, 1980.

"A Two-level Electricity Demand Model: Evaluation of the Connecticut Time-of-Day Pricing Test," delivered at EPRI Conference on Time of Day Pricing; with D. McFadden, in EPRI Report, Modeling and Analysis of Electricity Demand by Time of Day, 1979; Journal of Econometrics, 1979.

"Assessing the Potential Demand for Electric Cars," with S. Beggs and S. Cardell, presented at EPRI Conference, November 1979; Journal of Econometrics, 1981.

"Assessment and Validation of Energy Models," presented at EIA-NBS conference on Energy Models, May 1980; in Validation and Assessment of Energy Models, ed. S. Gass, Washington: Department of Commerce, 1981.

"Exact Consumer Surplus and Deadweight Loss," working paper 1979, American Economic Review, 71, 1981.

"Appliance Purchase and Usage Adaptation to a Permanent Time of Day Electricity Rate Schedule," with J. Trimble, August 1983; Journal of Econometrics, 1984.

"Evaluating the Costs and Benefits of Appliance Efficiency Standards," with P. Joskow, MIT Energy Lab Working Paper, MIT-EL82005WP; American Economic Review, 72, 1982.

"Information Costs, Competition and Collective Ratemaking in the Motor Carrier Industry," presented at Conference On Consensual Decision Making, American University, August 1982; American University Law Review, 1983.

"An Overview of IFFS," presented at EIA-NBS Conference on Energy Models, August 1982; in <u>Intermediate Future Forecasting System</u>, ed. S. Gass et al., Washington: 1983.

PUBLICATIONS cont.:

"Choice of Conservation Actions in the AHS," November 1982; in <u>Energy Simulation Models</u>, ed. R. Crow, 1983.

"Patents and R&D: Searching for a Lag Structure," with B. Hall and Z. Griliches, in <u>Actes du Colloque Econometrie de la Recherce</u>, Paris: 1983.

"The Demand for Optional Local Measured Telephone Service," in <u>Adjusting to Regulatory, Pricing and Marketing Realities</u>, East Lansing: 1983.

"Patents and R&D: Is There a Lag?," with B. Hall and Z. Griliches, 1985; <u>International Economic Review</u>, 1986.

"Price Discrimination and Patent Policy," with J. MacKie-Mason, <u>Rand Journal of Economics</u>, 1988.

"Residential End-Use Load Shape Estimation from Whole-House Metered Data," <u>IEEE Transactions on Power Systems</u>, 1988 (with I. Schick, P. Vsoro, and M. Ruane).

"Competition in Telecommunications for Large Users in New York," with H. Ware and T. Tardiff, <u>Telecommunications in a Competitive Environment</u>, 1989.

"Innovation and International Trade Policy," <u>Oxford Review of Economic Policy</u>, 1988 (with J. MacKie-Mason).

"The Evolution of the Central Office Switch Industry," with W. E. Kohlberg, 1987; in ed. S. Bradley and J. Hausman, <u>Future Competition in Telecommunications</u>, 1989.

"Future Competition in Telecommunications," 1987; ed. S. Bradley and J. Hausman, <u>Future Competition in Telecommunications</u>, 1989.

"Joint Ventures, Strategic Alliances and Collaboration in Telecommunications," presented at International Conference on Joint Ventures in Telecommunications, October 1989, <u>Regulation</u>, 1991.

"An Ordered Probit Model of Intra-day Securities Trading," with A. Lo and C. MacKinlay, <u>Journal of Financial Economics</u>, 1992.

"A Proposed Method for Analyzing Competition Among Differentiated Products," with G. Leonard and J.D. Zona, <u>Antitrust Law Journal</u>, 60, 1992.

"Global Competition and Telecommunications," in Bradley, <u>et al.</u>, ed., <u>Globalization, Technology and Competition</u>, 1993.

"The Bell Operating Companies and AT&T Venture Abroad and British Telecom and Others Come to the US," presented at Harvard Business Conference on International Telecommunications, 1991, in Bradley, <u>et al.</u>, ed., <u>Globalization, Technology and Competition</u>, 1993.

"The Effects of the Breakup of AT&T on Telephone Penetration in the US," with T. Tardiff and A. Belinfante, <u>American Economic Review</u>, 1993.

"Competitive Analysis with Differentiated Products," with G. Leonard and D. Zona, <u>Annales, D'Economie et de Statistique</u>, 34, 1994.

"Proliferation of Networks in Telecommunications," ed. D. Alexander and W. Sichel, <u>Networks, Infrastructure, and the New Task for Regulation</u>, presented at Conference 1994, University of Michigan Press, 1996.

"Valuation of New Goods Under Perfect and Imperfect Competition," MIT Working Paper, June, 1994, ed. T. Bresnahan and R. Gordon, <u>The Economics of New Goods</u>, University of Chicago Press, 1997.

"Competition in Long Distance and Equipment Markets: Effects of the MFJ," 1994, <u>Journal of Managerial and Decision Economics</u>, 1995.

"The Cost of Cellular Telephone Regulation," MIT Working Paper, January 1995.

"State Regulation of Cellular Prices," <u>Wireless Communications Forum</u>, Volume III, April 1995.

"Efficient Local Exchange Competition," with T. Tardiff, <u>Antitrust Bulletin</u>, 1995.

"Superstars in the National Basketball Association: Economic Value and Policy," with G. Leonard, <u>Journal of Labor Economics</u>, 15, 4, 1997.

"Valuation of New Services in Telecommunications," with T. Tardiff, presented at OECD Conference in Toronto, June 1995, <u>The Economics of the Information Society</u>, ed. A. Dumort and J. Dryden, Office for Official Publications of the European Communities, Luxemborg, 1997.

"Market Definition Under Price Discrimination," with G. Leonard and C. Vellturo, <u>Antitrust Law Journal</u>, Vol. 64, 1996.

"Characteristics of Demand for Pharmaceutical Products: An Examination of Four Cephalosporins," with S. Fisher Ellison, I. Cockburn and Z. Griliches, <u>Rand Journal of Economics</u>, 28, 3, 1997.

"Telecommunications: Building the Infrastructure for Value Creation," S. Bradley and R. Nolan, eds. <u>Sense and Respond</u>, 1998.

"Achieving Competition: Antitrust Policy and Consumer Welfare," with G. Leonard, <u>World Economic Affairs</u>, Vol. 1, No. 2, 1997.

"The CPI Commission and New Goods," <u>The American Economic Review</u>, May 1997.

"Economic Analysis of Differentiated Products Mergers Using Real World Data," with G. Leonard, <u>George Mason Law Review</u>, 5, 3, 1997.

"Cellular Telephone, New Products and the CPI," National Bureau of Economic Research, Working Paper 5982, March 1997, <u>Journal of Business and Economics Statistics</u>, 1999.

"The Impact of Duality on Productive Efficiency and Innovation," with G. Leonard and J. Tirole, mimeo October 1997, revised May, 1999.

"Regulation by TSLRIC: Economic Effects on Investment and Innovation," <u>Multimedia Und Recht</u>, 1999.

"Efficiencies from the Consumer Viewpoint, " with G. Leonard, <u>George Mason Law Review</u>, 1999.

"The Effect of Sunk Costs in Telecommunication Regulation," presented at Columbia University Conference, October, 1998. Published in J. Alleman and E. Noam, eds, <u>The New Investment Theory of Real Options and its Implications for Telecommunications Economics</u>, 1999.

"A Consumer-Welfare Approach to the Mandatory Unbundling of Telecommunications Networks," with J. Gregory Sidak, <u>Yale Law Journal</u>, 1999.

JOINT REPORTS, TESTIMONY, AND BOOKS:

"Project Independence: An Economic Analysis," <u>Technology Review</u>, May 1974.

"The FEA's Project Independence Report: Testimony before Joint Economic Committee," U.S. Congress, March 18, 1975.

"The FEA's Project Independence Report: An Analytical Assessment and Evaluation," NSF Report, June 1975.

"Energy Demand in the ERDA Plan," with D. Wood, Energy Laboratory Report, August 1975.

"A Note on Computational Simplifications and Extensions of the Conditional Probit Model," EPRI report on choice models, September 1977.

"Labor Supply Response of Males to a Negative Income Tax," Testimony for U.S. Senate Finance Subcommittee on Public Assistance, November 22, 1978.

"Appliance Choice with Time of Day Pricing," Energy Laboratory Report, January 1980.

"Discrete Choice Models with Uncertain Attributes," Oak Ridge National Laboratories Report, January 1980.

"Individual Savings Behavior," with P. Diamond, Report to the National Commission on Social Security, May 1980.

"Wealth Accumulation and Retirement," with P. Diamond, Report to the Department of Labor, May 1982.

"A Review of IFFS," Report to the Energy Information Agency, February 1982.

"A Model of Heating System and Appliance Choice," with J. Berkovec and J. Rust, Report to the Department of Energy, December 1983.

"Labor Force Behavior of Older Men After Involuntary Job Loss," with L. Paquette, Report to Department of Health and Human Services, December 1985.

"Pollution and Work Days Lost," with D. Wise and B. Ostrow, NBER Working Paper, January 1984; Revised 1985.

"Demand for Interstate Long Distance Telephone Service," with A. Jafee and T. Tardiff, November 1985.

"Competition in the Information Market 1990", August 1990.

"The Welfare Cost to the US Economy of Regulatory Restriction in Telecommunications," January 1995.

"Benefits and Costs of Vertical Integration of Basic and Enhanced Telecommunications Services," April 1995.

"Statement on the Natural Resource Damage Provisions of CERCLA," Testimony before the U.S. Senate Committee on Environment and Public Works, May 11, 1995; Testimony before the U.S. House of Representatives, Transportation & Infrastructure Committee, Water Resources & Environment Subcommittee, July 11, 1995.

"Competition in Cellular Markets," Testimony before the U.S. House of Representatives, Committee on Commerce, October 12, 1995.

"Merger Policy in Declining Demand Industries," Testimony before the U.S. Federal Trade Commission, November 14, 1995.

"Expected Results from Early Auctions of Television Spectrums," Testimony before the U.S. Senate Budget Committee and the U.S. House of Representatives, Committee on Commerce, March 13, 1996.

The Choice and Utilization of Energy Using Durables, ed. J. Hausman, Palo Alto: EPRI, 1981.

Social Experimentation, ed. J. Hausman and D. Wise, Chicago: 1985.

Future Competition in Telecommunications, ed. S. Bradley and J. Hausman, Harvard: 1989.

Contingent Valuation: A Critical Appraisal, ed. J. Hausman, North Holland, 1993.

Globalization, Technology and Competition, ed. S. Bradley, J. Hausman, R. Nolan, Harvard 1993.

Economic Impact of Deregulating U.S. Communications Industries, The WEFA Group, Burlington, MA, February 1995.

Econometric Model and Calculation of Post-Merger Price Changes

We specified a two-stage "discrete/continuous" model of consumer demand for long distance services. These models have previously been used by Hausman (1979), Duncan (1980), and Dubin and McFadden (1984), although not in the long distance context.[1] In the first, "carrier choice," stage, the consumer chooses a long-distance carrier. In the second, "usage," stage, the consumer chooses the amount of long-distance minutes. We estimated the model using a dataset consisting of information on the monthly bills of approximately 20,000 individual consumers collected by PNR in their Bill Harvesting data set.[2]

A.   The Carrier Choice Stage

In the carrier choice stage, the consumer is assumed to choose among carriers based on carrier attributes. The choice set faced by consumers was assumed to include four alternatives: (1) AT&T, (2) MCI/WorldCom, (3) Sprint, and (4) the dial-around ("10-10") carriers including other long distance carriers (e.g. Qwest), who are grouped into one alternative. We assume that consumers choose the carrier that maximizes their utility. If consumer i chooses carrier j, consumer i is assumed to get utility equal to

$$(1) \qquad\qquad V_{ij} = Z_{ij}\beta + \alpha_j + \varepsilon_{ij}$$

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[1] See J. Hausman, "Individual Discount Rates and the Purchase and Utilization of Energy Using Durables," *Bell Journal of Economics*, 1979; G. Duncan, "Formulation and Statistical Analysis of the Mixed, Continuous/Discrete Dependent Variable Model in Classical Production Theory," *Econometrica*, 1980; J. Dubin and D. McFadden, "An Econometric Analysis of Residential Electric Appliance Holdings and Consumption," *Econometrica*, 1984. For a review, see J. Hausman, "The Econometrics of Nonlinear Budget Sets," *Econometrica*, 1985.

[2] These data are used by the FCC to estimated residential long distance market shares; e.g. FCC Industry Analysis Division, "Long Distance Market Shares", Fourth Quarter 1998, March 1999, Table 4.3

where Z_{ij} are the attributes of carrier j that are specific to consumer i, e.g., the price of

carrier j, α_j is a carrier-specific parameter that captures all attributes of the carrier that are

the same across consumers, e.g., brand name, and ε_{ij} is an unobserved variable specific to

individual i and carrier j.[3] The inclusion of the carrier specific parameter allows

estimation of the effect of brand name on consumer choice. Our empirical results

demonstrate that brand name has a large and statistically significant effect on consumer

choice of carrier.

We estimated the parameters in equation (1) using maximum likelihood methods

given a distributional assumption for the ε_{ij}. We employed three alternative distributional

assumptions. First, we used the independent extreme value distribution, which yields the

multinomial logit (MNL) model. Next, we used the generalized extreme value

distribution, which leads to the nested logit (NL) model; see McFadden (1984).[4] Lastly,

we used the multivariate normal distribution, which yields the multinomial probit (MNP)

model; see Hausman and Wise (1978).[5] The MNP model allows for a more flexible

pattern of cross price elasticities of demand than the MNL and NL models.[6]

B.   The Usage Choice Stage

In the usage choice stage, the consumer chooses number of long-distance minutes.

This choice is assumed to be a function of price of the chosen carrier as well as

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[3] Carriers offer plans with different prices for different times of day. We determined carrier prices for the peak, off-peak/non-Sunday, and off-peak/Sunday periods and included these variables in the Z_{ij} vector.
[4] D. McFadden, "Econometric Analysis of Qualitative Response Models," in *Handbook of Econometrics*, ed. by Z. Griliches and M. Intriligator, 1984.
[5] J. Hausman and D. Wise, "A Conditional Probit Model for Qualitative Choice," *Econometrica*, 1978.
[6] The MNL model implies equal cross elasticities across carriers. See J. Hausman, "Project Independence Report: A Review of U.S. Energy Needs up to 1985," *Bell Journal of Economics*, 1975.

characteristics of the consumer such as income, age, and education. The econometric specification for the usage choice stage is

$$(2) \qquad\qquad M_i = \gamma P_i + X_i \beta + v_i$$

where M_i is the number of minutes chosen by consumer i, P_i is the price of the carrier chosen by consumer i in the first stage, X_i is a vector of demographic characteristics of consumer i, and v_i is an error term accounting for unobserved factors that affect consumer i's choice of minutes.

The use of least squares to estimate the parameters in equation (2) would yield biased and inconsistent estimates in general because the consumer's choice of carrier in the first stage implies a correlation between the price of the chosen carrier, P_i, and the unobserved factors that affect choice of minutes, v_i. Thus, we used an instrumental variables (IV) method to estimate equation (2). The predicted choice probabilities for the four carriers from the first stage, each multiplied by the respective carrier price, are used as instruments for the chosen price P_i.

C. Calculation of Post-Merger Price Changes

Given the two-stage demand model described above, carrier j faces a demand for minutes equal to

$$(3) \qquad\qquad Q_j = N \, \pi_j(P_1,P_2,P_3,P_4) \, M_j(P_j)$$

where N is the number of consumers, π_j is the percentage of consumers choosing carrier j, which depends on the prices of all four carriers, and $M_j(P_j)$ is the average minutes of usage for consumers choosing carrier j, which depends on the price of carrier j only. In what follows, we set N = 1 without loss of generality. The following table gives the estimated own and cross-price elasticities of demand for each carrier based on the

parameter estimates from the two-stage demand model and pre-merger prices. We present

the results from the multivariate probit model since it allows for the most flexible

specification of cross price elasticities:

Estimates of own Price and Cross Price Elasticities[7]

	Other Carriers	AT&T	MCI	Sprint
Dial Around	-1.33	0.47	0.12	0.04
AT&T	0.16	-1.12	0.09	0.03
MCI	0.23	0.50	-1.33	0.06
Sprint	0.30	0.61	0.22	-1.81
Pre-merger quantity shares	15.2%	63.4%	16.4%	5.0%

Note that Sprint is the closest competitor with MCI with its cross price elasticity almost

twice as large as the next closest competitor. Also, MCI is the closest competitor to

Sprint.[8]

Pre-merger, carrier j chooses its price P_j to maximize profits. Under the assumed

Nash-Bertrand pricing model, the first order conditions for the carriers' maximization

problems lead to a system of four equations of the form

(4) $E_{jj} (P_j - C_j)/P_j = -1$

where C_j is the marginal cost of carrier j and E_{jj} is the own price elasticity of demand

faced by carrier j.[9] Given the pre-merger prices and the own elasticities calculated from

the demand equation (3), we can solve for the implied marginal costs C_i.

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[7] The cross price elasticities are calculated as the log change in the quantity of the row with respect to the log change in the price of the column, e.g. 0.22 represents approximately a 2.2% change in Sprint's quantity for a 10% change in MCI's price. Thus, the largest effect of a MCI price change is on Sprint, and the largest effect of a Sprint price change is one MCI.

[8] Similar results were found with the NL model specification, e.g. Sprint and MCI were again each others' closes substitutes.

[9] For further explanation of this analysis, see J. Hausman and G. Leonard, "Economic Analysis of Differentiated Products Mergers Using Real World Data," *George Mason Law Review*, 1997 and J.

Post-merger, the combined MCI-Sprint entity will take into account the cross elasticity of demand between the MCI and Sprint services when setting prices. Thus, the first order condition for the Sprint price will be

(5) $$S_s \, E_{ss} \, (P_s - C_s)/P_s + S_m \, E_{ms} \, (P_m - C_m)/P_m = -S_s$$

where the subscripts "s" and "m" indicate Sprint and MCI respectively, S_j is the revenue share of carrier j, and E_{ms} is the elasticity of MCI demand with respect to Sprint's price. A similar first order condition holds for MCI. The post-merger equilibrium prices solve the system of four equations consisting of the first order conditions of form (4) for AT&T and the 10-10s and the first order conditions of form (5) for MCI and Sprint.
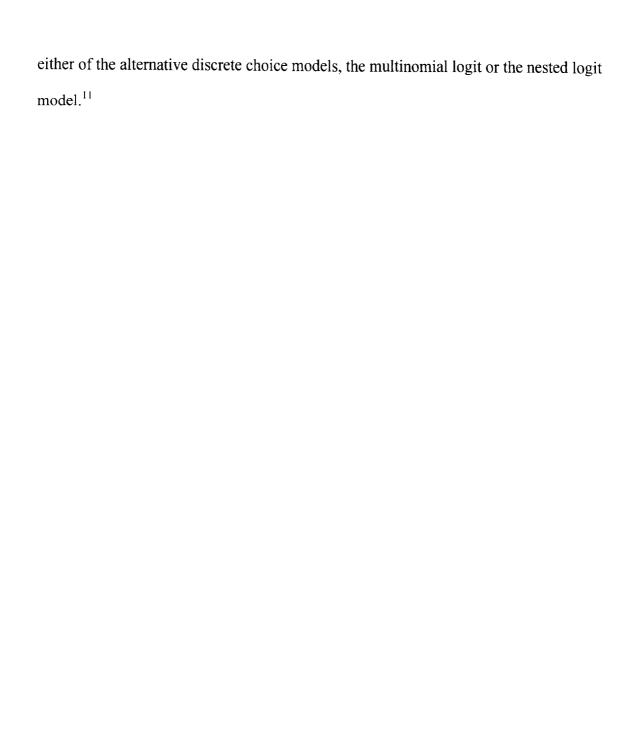
Using the parameters of the two-stage demand system, along with the implied marginal costs calculated as described above, we estimated the following post-merger price changes:[10]

Carrier	Percent Increase
MCI	5.4%
Sprint	8.9%

Thus, we find a larger expected price increase for Sprint than for MCI, which is the usual result since MCI is significantly larger than Sprint. The result of the proposed merger would lead to significantly higher prices for residential consumers. We find approximately similar results when we based the estimated post-merger price changes on

Hausman, G. Leonard, and D. Zona, "Competitive Analysis with Differentiated Products," *Annales D'Economie et de Statistique*, 1994.
[10] In doing this calculation we assume that the dial around carriers are independent of MCI. In fact, MCI owns the largest dial around carrier, which has 45% of dial around sales. This control could lead to a larger price increase.

either of the alternative discrete choice models, the multinomial logit or the nested logit

model.[11]

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[11] I find somewhat higher estimates of the post-merger price change using the multinomial probit model.
This finding corresponds to the empirical finding that MCI and Sprint are each others' closest competitors.